LET'S REVIEW

SOIL CLASSIFICATION

ENGR. DARIO A. CALAQUE, JR

PREPARED BY: ENGR. DARIO A. CALAQUE, JR

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Particle Size Distribution: Sieve Analysis

Sieve Analysis consists of shaking the soil sample through a set of sieves that have progressively smaller openings. These sieves are generally 200 mm in diameter.

To conduct a sieve analysis, the soil is first oven-dried and then all lumps must be broken into smaller particles. The soil is then shaken through a stack of sieves with openings of decreasing size from top to bottom. The pan is placed below the stack.

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US Standard Sieve Size	
Sieve No	Opening (mm)
GRAVEL (USCS)	
4	4.75
6	3.35
GRAVEL (USDA&AASHTO)	
10	2
16	1.18
20	0.85
30	0.6
40	0.425
50	0.3
60	0.25
80	0.18
100	0.15
140	0.106
SAND(USCS&AASHTO)	.088
200	0.074
270	0.053

SAND(USDA)

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100%

100%

%GRAVEL

SOIL RETAINED
GRAVEL

%COARSE

NO.10
2mm opening

%SAND

SOIL PASS THRU
SAND

NO.270
0.05mm opening

%SILT & CLAY

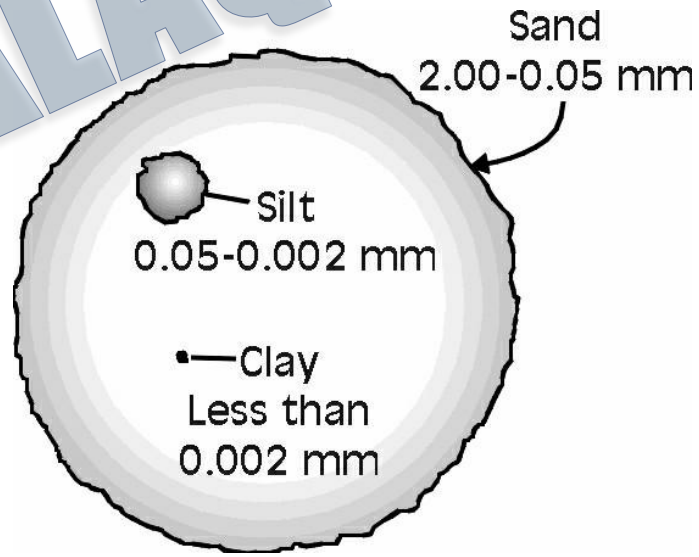
%FINE

0%

USDA

0%

USDA = United States of Department of Agriculture



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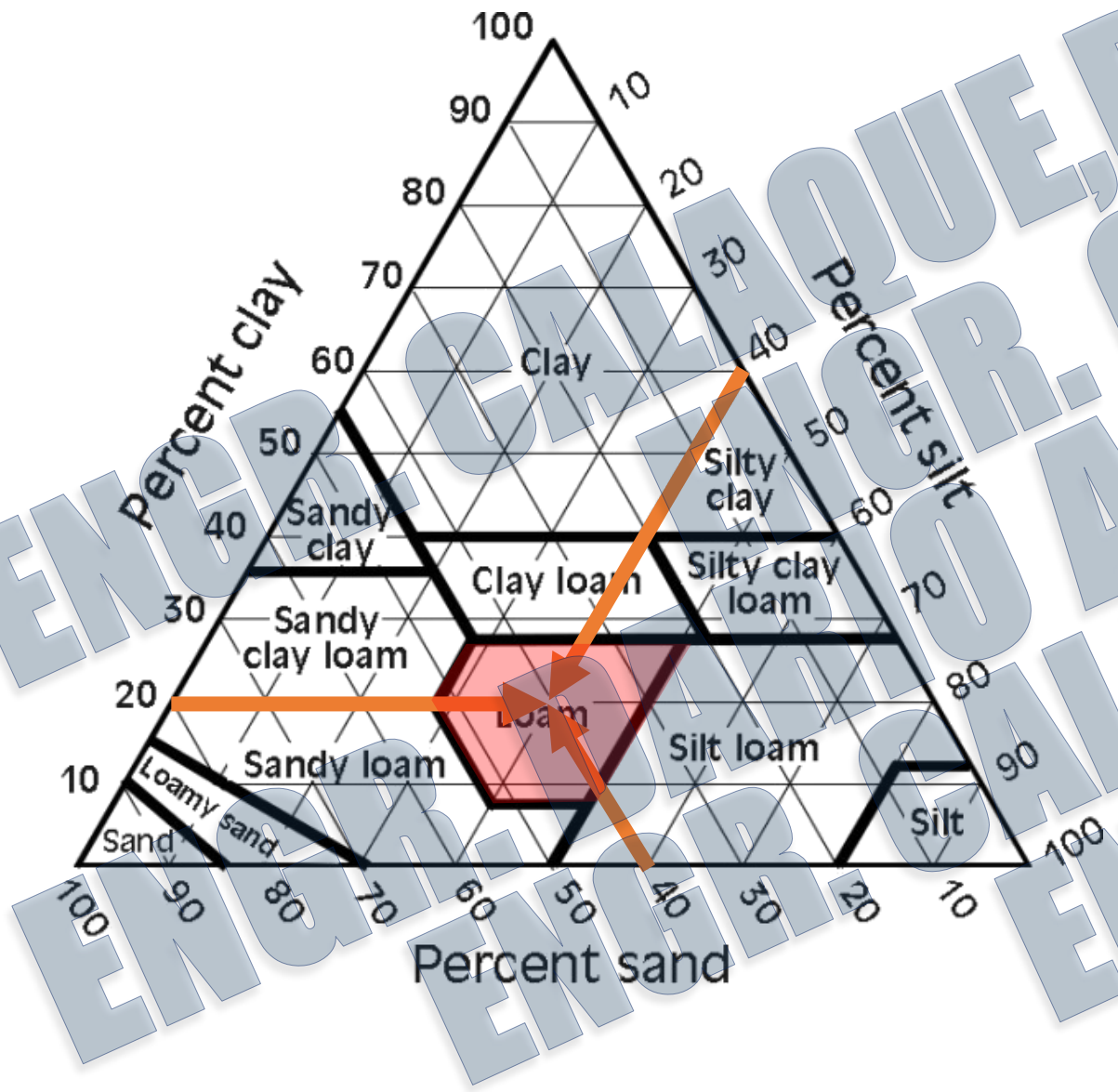
US Department of Agriculture (USDA): Triangular Textural Classification Chart



A **textural triangle** is used to describe soil texture. The three sides of the triangle represent the percentages of sand, silt, or clay. The intersection points of three lines from each side of the triangle determine how the soil texture will be classified.

For example, if a soil has 20 percent clay, 40 percent sand, and 40 percent silt, it is a loam (*see the triangle in the area labeled loam*).

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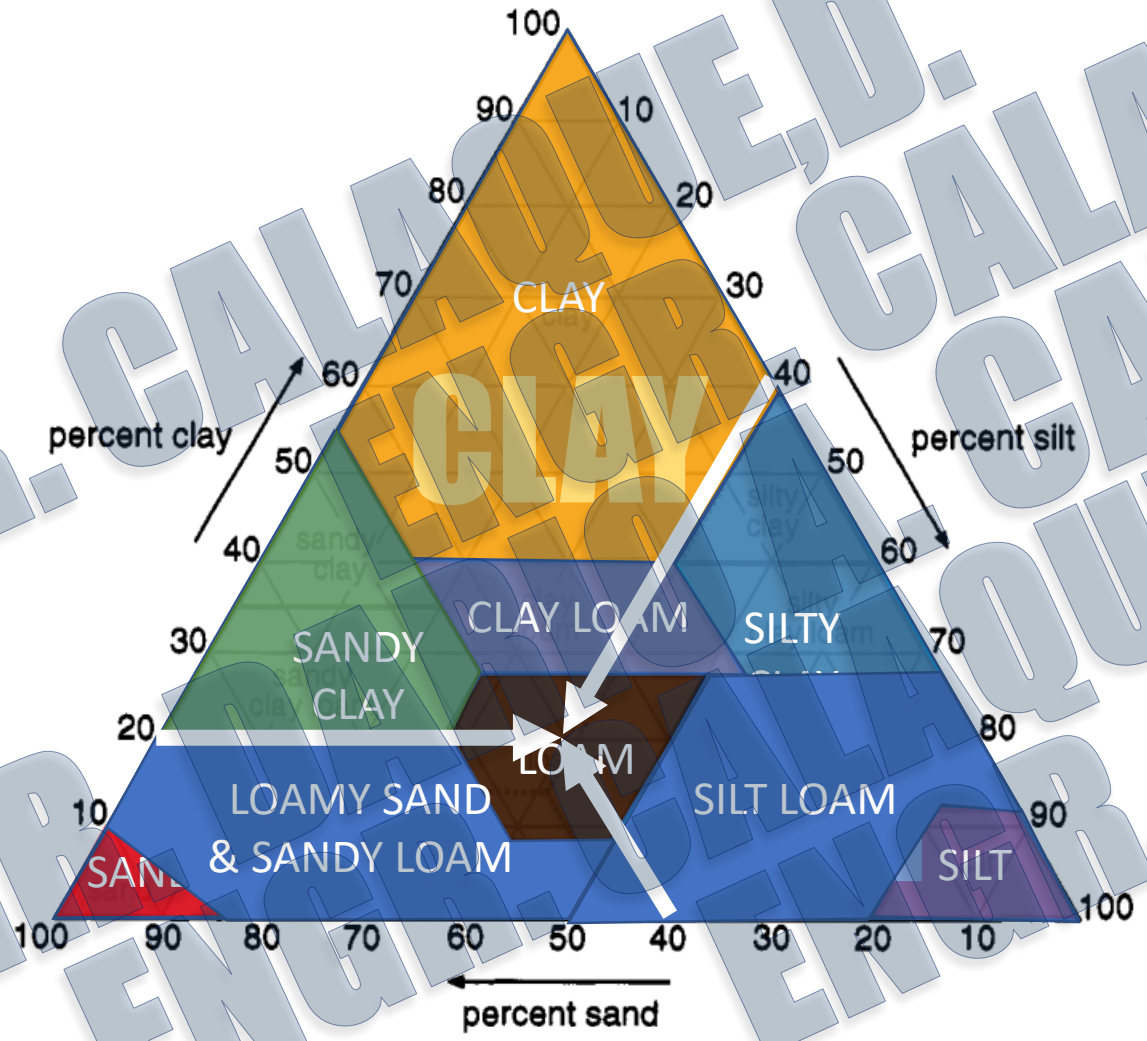
If a soil has 20 percent clay, 40 percent sand, and 40 percent silt, it is a loam



This method is based on the following limits of particle size:

Sand size: 2.0 to 0.05 mm in diameter

Silt size: 0.05 to 0.002 mm in diameter

Clay size: smaller than 0.002 mm in diameter

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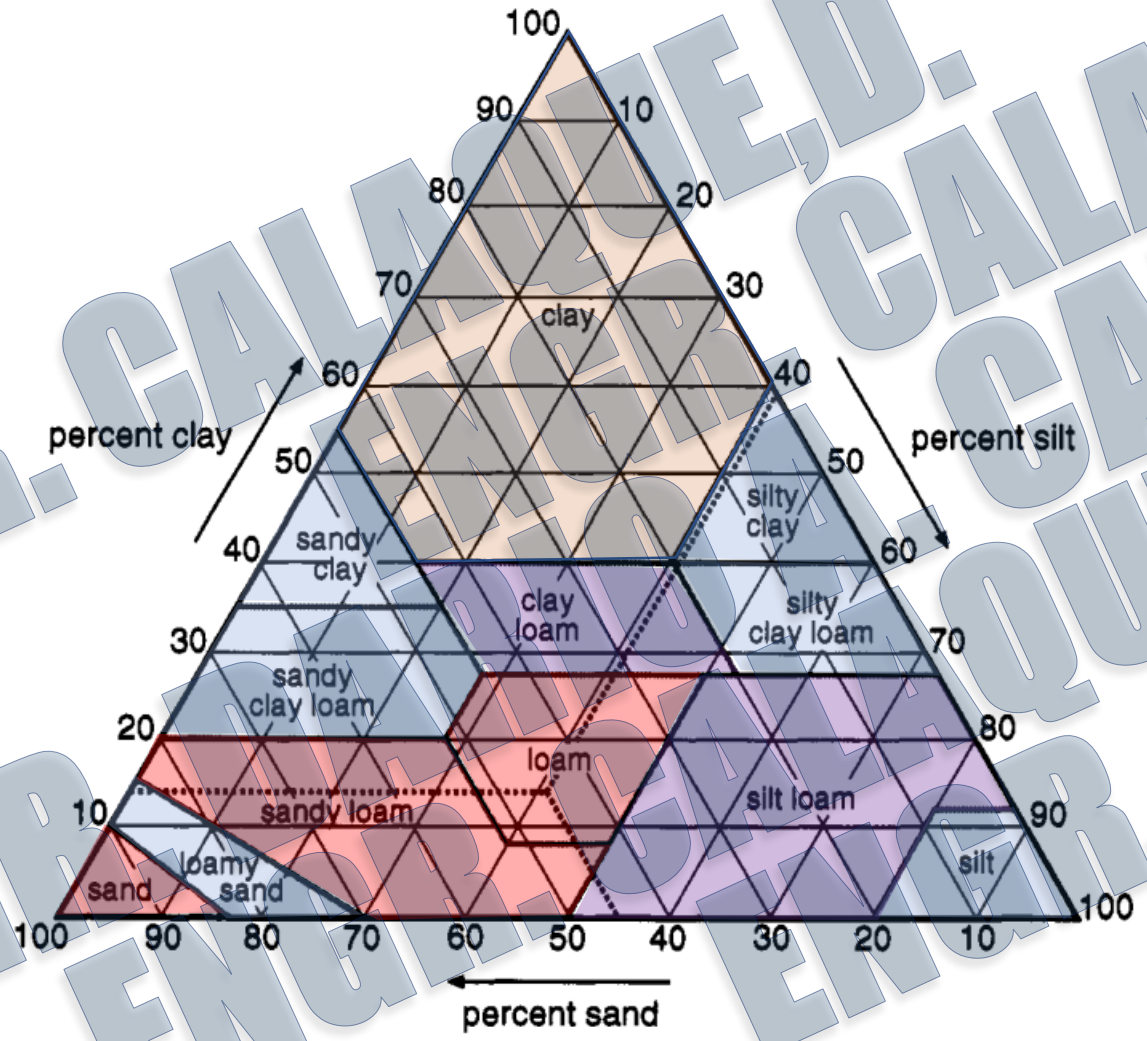
If a soil has 20 percent clay, 40 percent sand, and 40 percent silt, it is a loam



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Clay size: smaller than 0.002 mm in diameter

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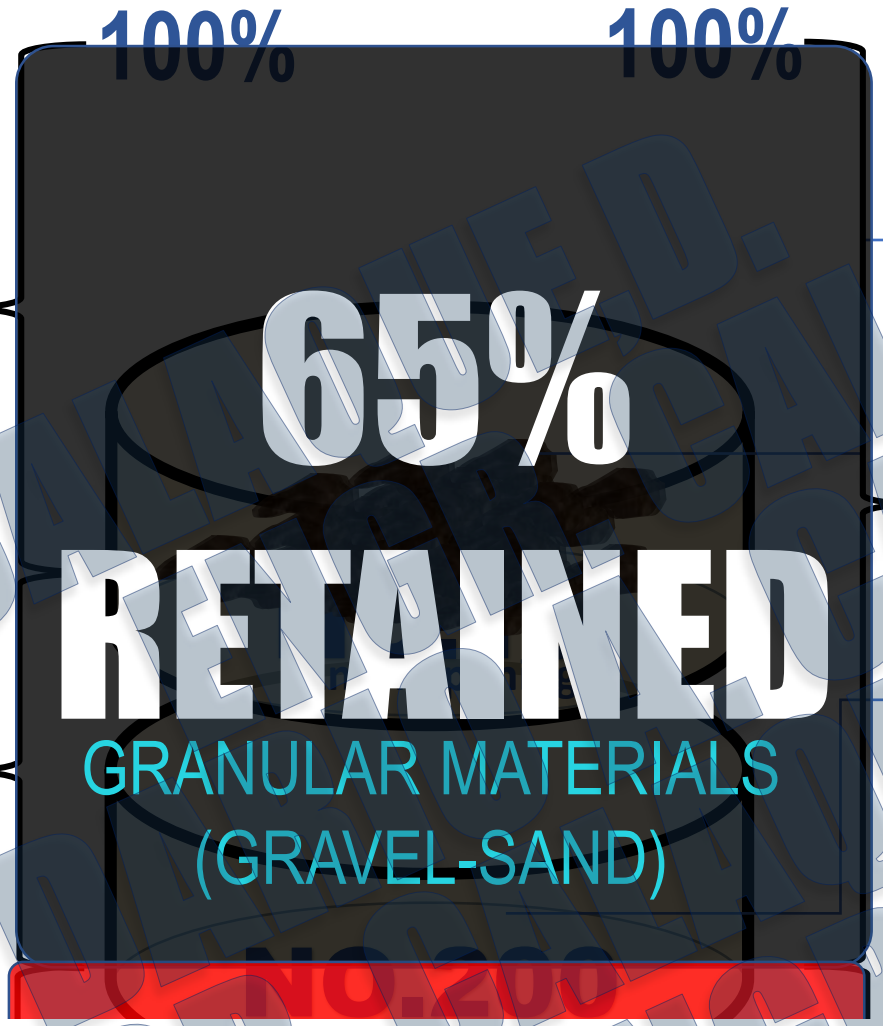

%GRAVEL

%SAND

SOIL RETAINED
GRAVEL

%COARSE

SOIL PASS THRU
SAND

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General classification	Granular materials (35% or less of total sample passing No. 200)						
	A-1			A-2			
Group classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7

AASHTO Classification System

Table 5.1 Classification of Highway Subgrade Materials

General classification	Granular materials (35% or less of total sample passing No. 200)						
	A-1			A-2			
Group classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7
Sieve analysis (percentage passing)							
No. 10	50 max.						
No. 40	30 max.	50 max.	51 min.				
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.
Characteristics of fraction passing No. 40							
Liquid limit				40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		NP	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Stone, fragments, gravel and sand		Fine sand	Silty or clayey gravel, and sand			
General subgrade rating	Excellent to good						

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General classification	Silt-clay materials (more than 35% of total sample passing No. 200)			
Group classification	A-4	A-5	A-6	A-7 A-7-5[a] A-7-6[b]

%COARSE

%SAND

SOIL PASS THRU
SAND

%SILT & CLAY

>35% PASSING
SILT-CLAY MATERIALS

%FINE

0% AASHTO 0%

AASHTO = American Association of State Highway and Transportation Officials

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AASHTO Classification System

General classification	Silt-clay materials (more than 35% of total sample passing No. 200)			
Group classification	A-4	A-5	A-6	A-7 A-7-5[a] A-7-6[b]
Sieve analysis (percentage passing)				
No. 10				
No. 40				
No. 200	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40				
Liquid limit	40 max.	41 min.	40 max.	41 min.
Plasticity index	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Silty soils		Clayey soils	
General subgrade rating	Fair to poor			

[a]For A-7-5, $PI \leq LL - 30$

[b]For A-7-6, $PI > LL - 30$

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AASHTO Classification System

Group Index (GI) :

- The group index of soils belonging to groups *A-1-a*, *A-1-b*, *A-2-4*, *A-2-5*, and *A-3* is always 0.

- When calculating the group index for soils that belong to groups A-2-6 and A-2-7,

$$GI = 0.01(F_{200} - 15)(PI - 10)$$

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AASHTO Classification System

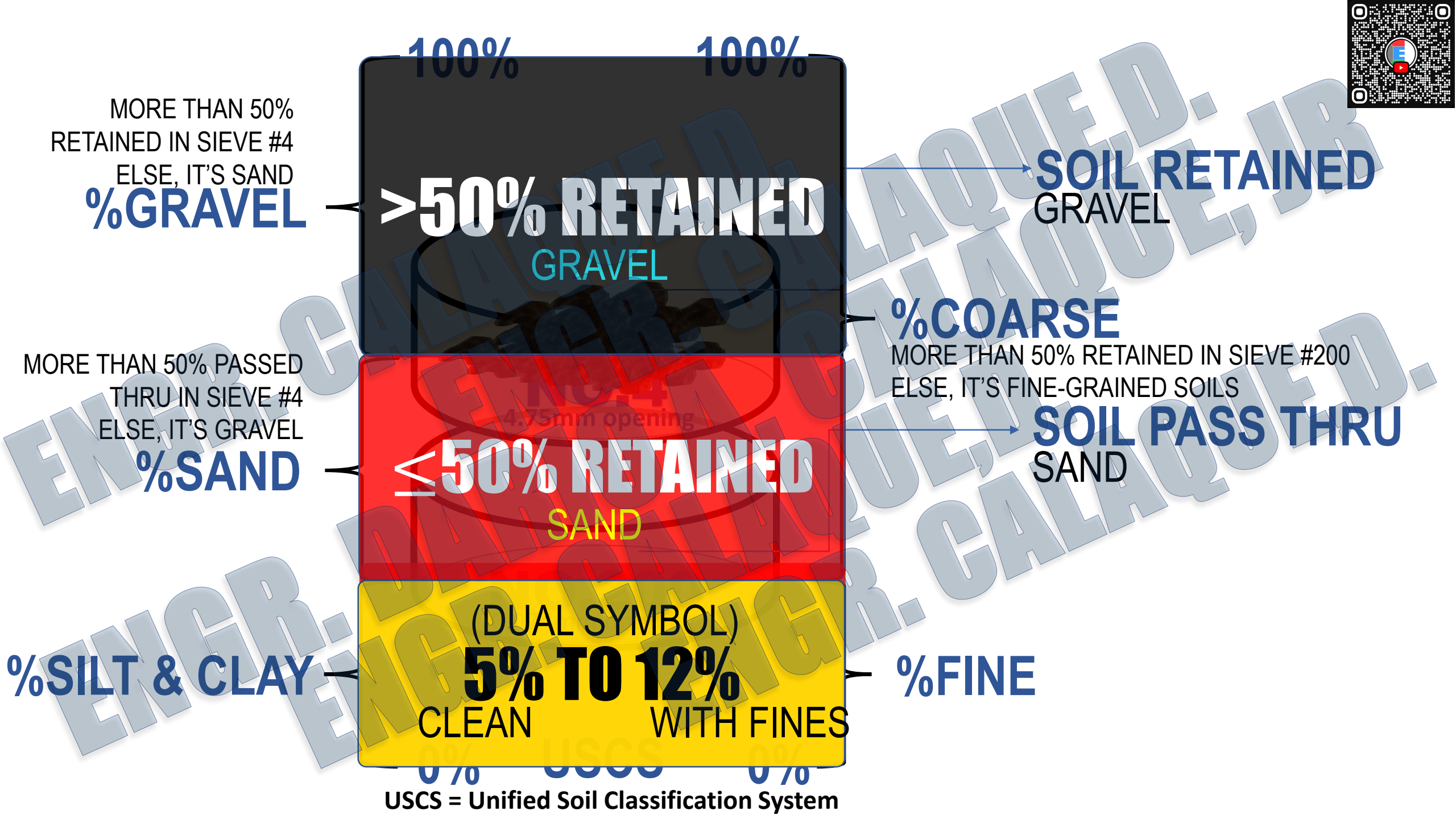
Group Index (GI) :

- For any other groups:

$$GI = (F_{200} - 35)[0.2 + 0.005(LL - 40)] + 0.01(F_{200} - 15)(PI - 10)$$

where: $F_{200} = Passing\ No.200$; $LL =$ $Liquid\ Limit$; $PI = Plastic\ Index$

- If the GI eq. yields a negative value, it is taken as 0.
- The GI rounded off to the nearest whole number (for example, GI = 3.4 is rounded off to 3; GI= 3.5 is rounded off to 4).



USCS = Unified Soil Classification System

Unified Soil Classification System (USCS)

Table 5.2 Unified Soil Classification System (Based on Material Passing 76.2-mm Sieve)

Criteria for assigning group symbols				Group symbol
Coarse-grained soils More than 50% retained on No. 200 sieve	**Gravels** More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[a]	$C_u \geq 4$ and $1 \leq C_c \leq 3$[c]	GW
			$C_u < 4$ and/or $C_c < 1$ or $C_c > 3$[c]	GP
		Gravels with Fines More than 12% fines[a,d]	$PI < 4$ or plots below "A" line (Figure 5.3)	GM
			$PI > 7$ and plots on or above "A" line (Figure 5.3)	GC
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[b]	$C_u \geq 6$ and $1 \leq C_c \leq 3$[c]	SW
			$C_u < 6$ and/or $C_c < 1$ or $C_c > 3$[c]	SP
		Sands with Fines More than 12% fines[b,d]	$PI < 4$ or plots below "A" line (Figure 5.3)	SM
			$PI > 7$ and plots on or above "A" line (Figure 5.3)	SC
Fine-grained soils 50% or more passes No. 200 sieve	**Silts and clays** Liquid limit less than 50	Inorganic	$PI > 7$ and plots on or above "A" line (Figure 5.3)[e]	CL
			$PI < 4$ or plots below "A" line (Figure 5.3)[e]	ML
		Organic	$\frac{\text{Liquid limit—oven dried}}{\text{Liquid limit—not dried}} < 0.75$; see Figure 5.3; OL zone	OL
	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line (Figure 5.3)	CH
			PI plots below "A" line (Figure 5.3)	MH
		Organic	$\frac{\text{Liquid limit—oven dried}}{\text{Liquid limit—not dried}} < 0.75$; see Figure 5.3; OH zone	OH
Highly organic soils	Primarily organic matter, dark in color, and organic odor			Pt

[a] Gravels with 5 to 12% fine require dual symbols: GW-GM, GW-GC, GP-GM, GP-GC.

[b] Sands with 5 to 12% fines require dual symbols: SW-SM, SW-SC, SP-SM, SP-SC.

[c] $C_u = \frac{D_{60}}{D_{10}}$; $C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}$

[d] If $4 \leq PI \leq 7$ and plots in the hatched area in Figure 5.3, use dual symbol GC-GM or SC-SM.

[e] If $4 \leq PI \leq 7$ and plots in the hatched area in Figure 5.3, use dual symbol CL-ML.

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Unified Soil Classification System (USCS)

76.2-mm Sieve)

Group symbol

$C_u \geq 4$ and $1 \leq C_c \leq 3^c$ — GW Well-graded
$C_u < 4$ and/or $C_c < 1$ or $C_c > 3^c$ — GP Poorly-graded

$PI < 4$ or plots below "A" line (Figure 5.3) — GM Silty
$PI > 7$ and plots on or above "A" line (Figure 5.3) — GC Clayey

6LETTERS
GRAVEL

$C_u \geq 6$ and $1 \leq C_c \leq 3^c$ — SW Well-graded
$C_u < 6$ and/or $C_c < 1$ or $C_c > 3^c$ — SP Poorly-graded

$PI < 4$ or plots below "A" line (Figure 5.3) — SM Silty
$PI > 7$ and plots on or above "A" line (Figure 5.3) — SC Clayey

4LETTERS
SAND

$PI > 7$ and plots on or above "A" line (Figure 5.3)^e — CL
$PI < 4$ or plots below "A" line (Figure 5.3)^e — ML

$\frac{\text{Liquid limit—oven dried}}{\text{Liquid limit—not dried}} < 0.75$; see Figure 5.3; OL zone — OL

FOR WELL-GRADED SOIL

COEFF.OF UNIFORMITY
$C_u \geq 4$

COEFF.OF CURVATURE
$1 \leq C_c \leq 3$

COEFF.OF UNIFORMITY
$C_u \geq 6$

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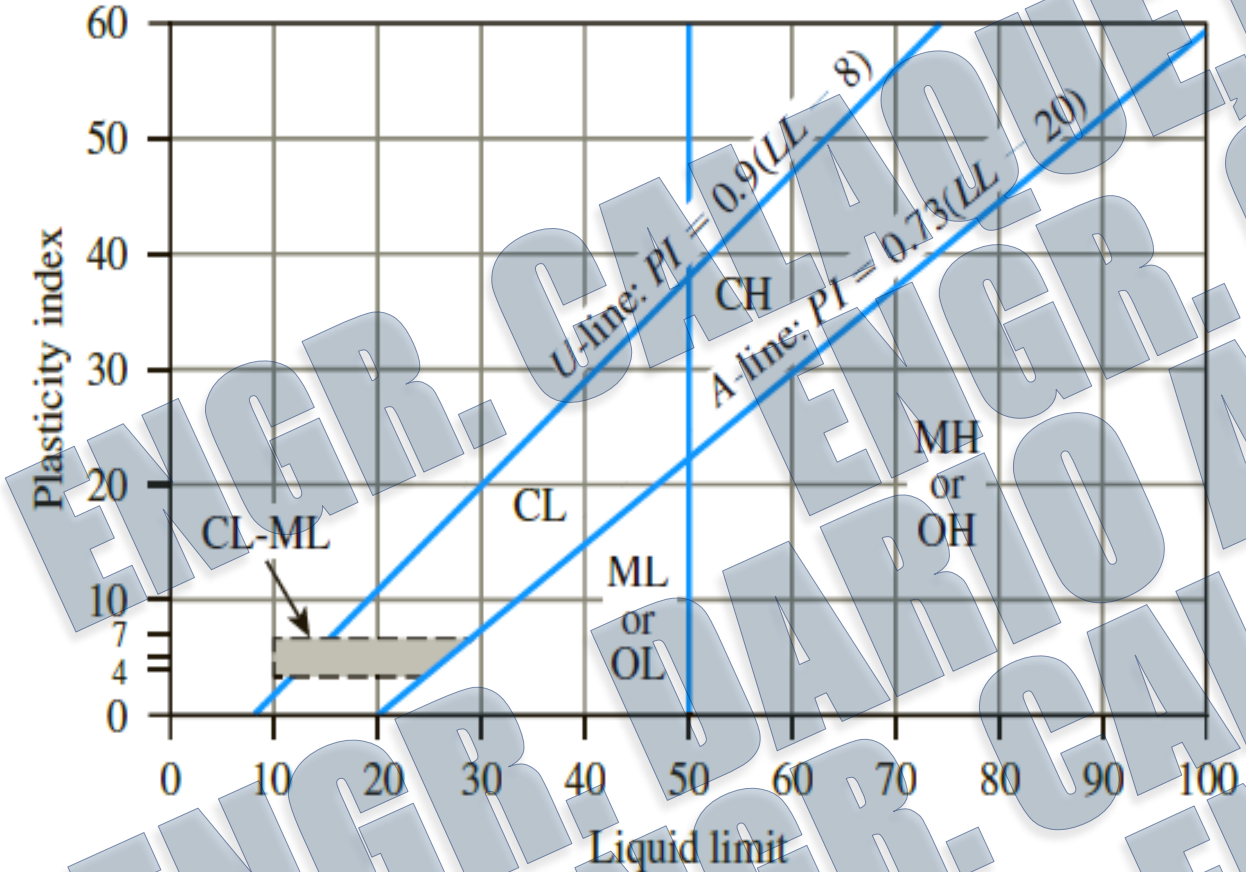
Unified Soil Classification System (USCS)



GW	<15% sand	Well-graded gravel
	≥15% sand	Well-graded gravel with sand
GP	<15% sand	Poorly graded gravel
	≥15% sand	Poorly graded gravel with sand
GW-GM	<15% sand	Well-graded gravel with silt
	≥15% sand	Well-graded gravel with silt and sand
GW-GC	<15% sand	Well-graded gravel with clay (or silty clay)
	≥15% sand	Well-graded gravel with clay and sand (or silty clay and sand)
GP-GM	<15% sand	Poorly graded gravel with silt
	≥15% sand	Poorly graded gravel with silt and sand
GP-GC	<15% sand	Poorly graded gravel with clay (or silty clay)
	≥15% sand	Poorly graded gravel with clay and sand (or silty clay and sand)
GM	<15% sand	Silty gravel
	≥15% sand	Silty gravel with sand
GC	<15% sand	Clayey gravel
	≥15% sand	Clayey gravel with sand
GC-GM	<15% sand	Silty clayey gravel
	≥15% sand	Silty clayey gravel with sand
SW	<15% gravel	Well-graded sand
	≥15% gravel	Well-graded sand with gravel
SP	<15% gravel	Poorly graded sand
	≥15% gravel	Poorly graded sand with gravel
SW-SM	<15% gravel	Well-graded sand with silt
	≥15% gravel	Well-graded sand with silt and gravel
SW-SC	<15% gravel	Well-graded sand with clay (or silty clay)
	≥15% gravel	Well-graded sand with clay and gravel (or silty clay and gravel)
SP-SM	<15% gravel	Poorly graded sand with silt
	≥15% gravel	Poorly graded sand with silt and gravel
SP-SC	<15% gravel	Poorly graded sand with clay (or silty clay)
	≥15% gravel	Poorly graded sand with clay and gravel (or silty clay and gravel)
SM	<15% gravel	Silty sand
	≥15% gravel	Silty sand with gravel
SC	<15% gravel	Clayey sand
	≥15% gravel	Clayey sand with gravel
SC-SM	<15% gravel	Silty clayey sand
	≥15% gravel	Silty clayey sand with gravel

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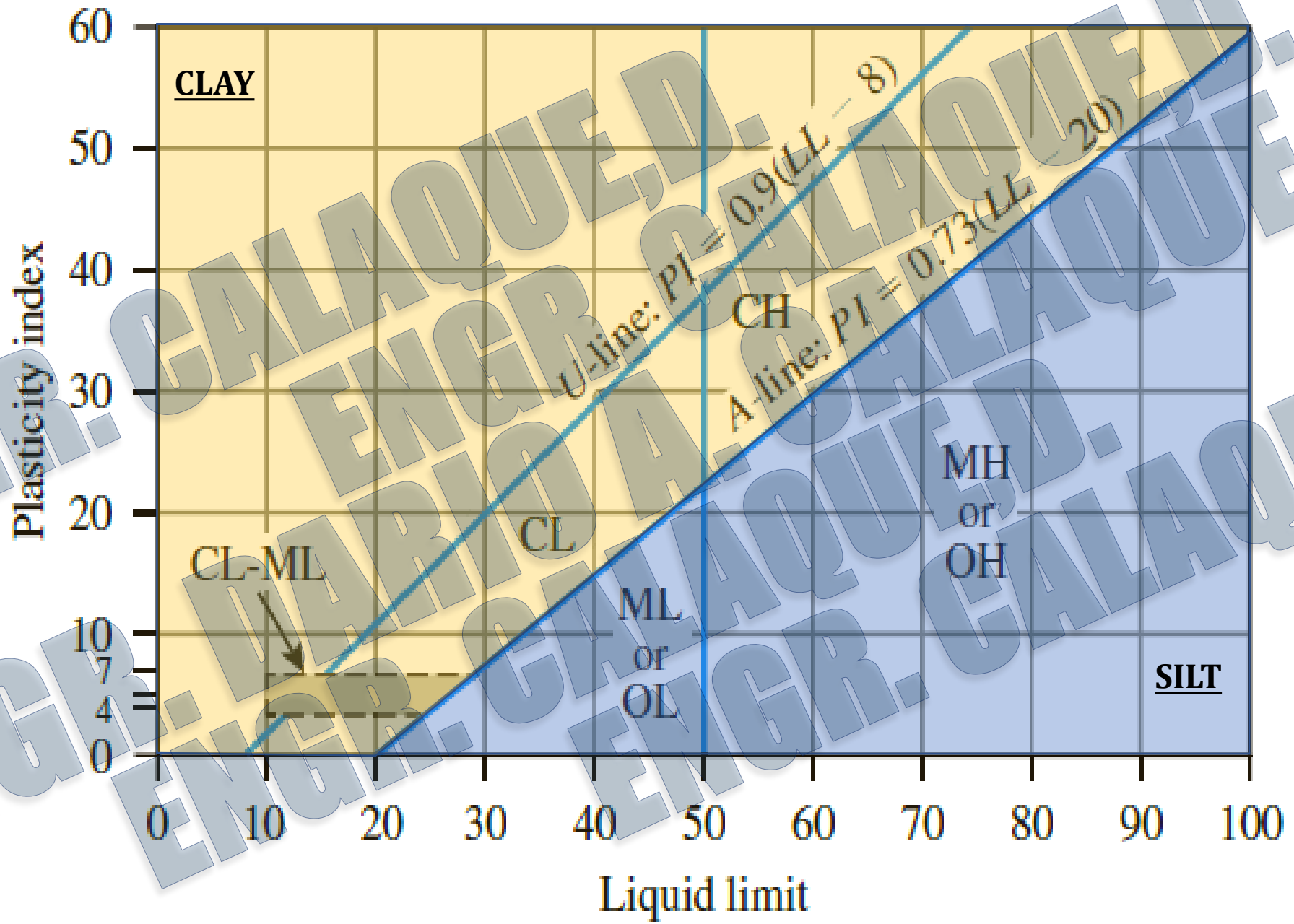
Unified Soil Classification System (USCS)



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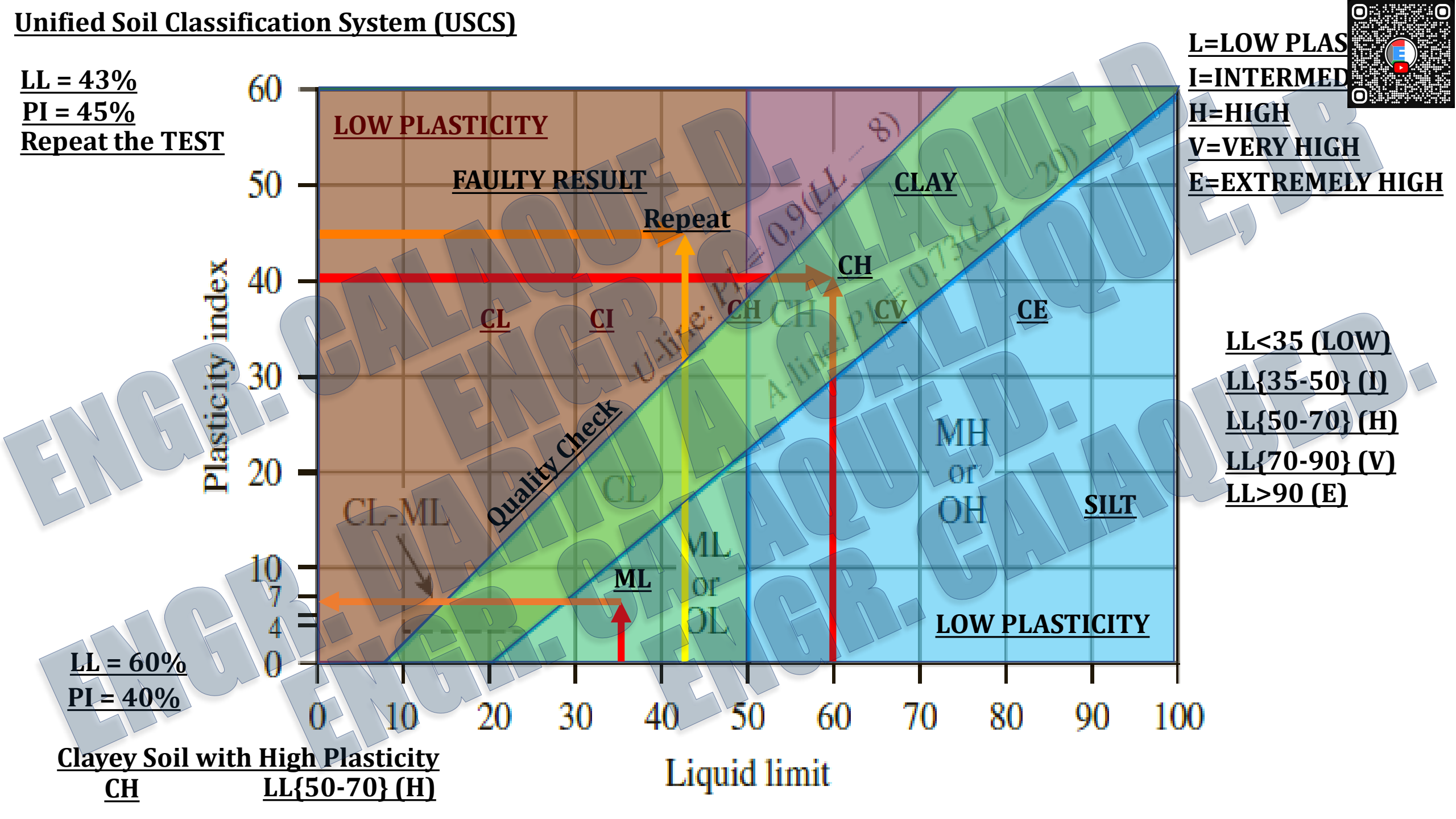
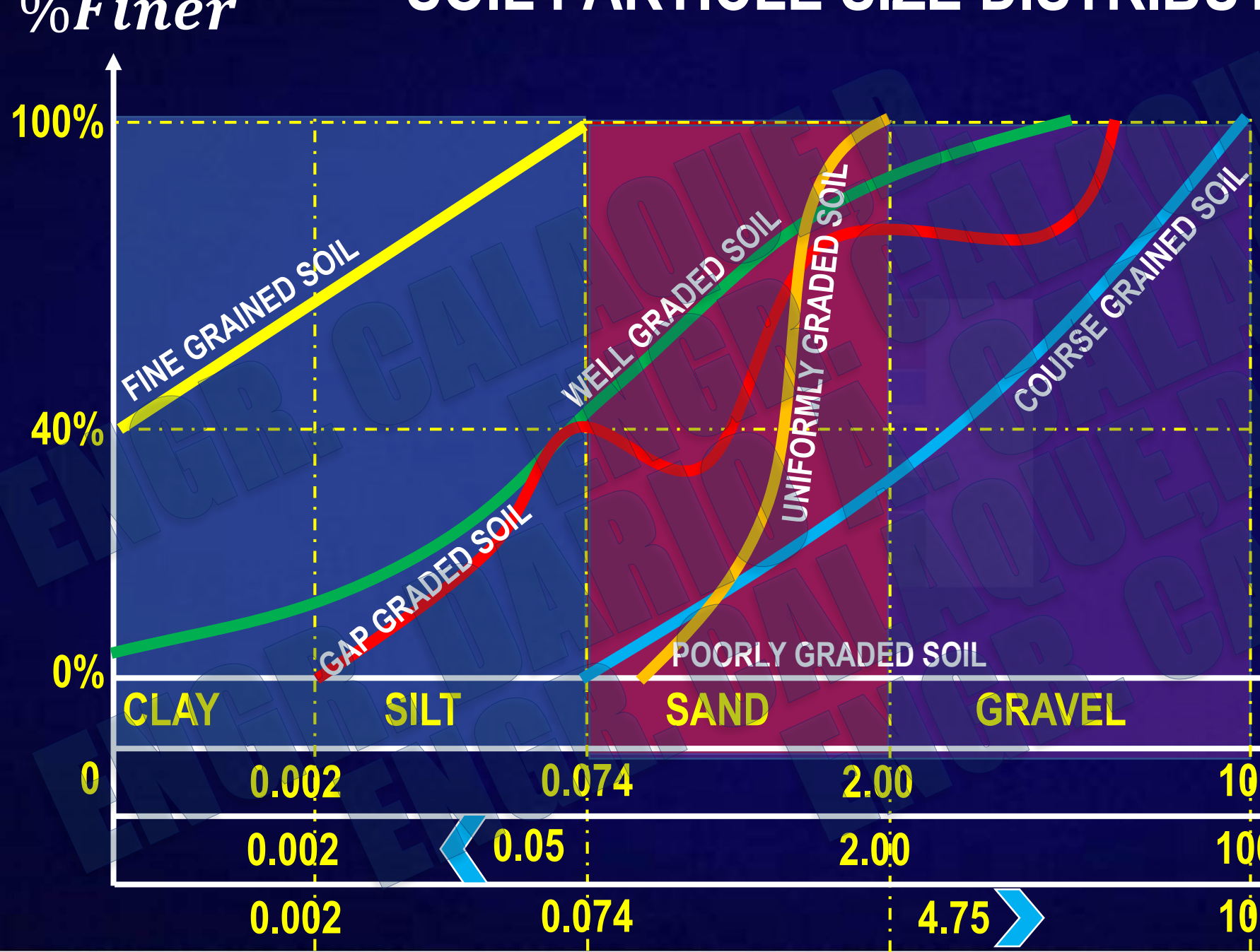
Unified Soil Classification System (USCS)



Clayey Soil with High Plasticity

CH LL{50-70} (H)

SOIL PARTICLE SIZE DISTRIBUTION



USDA = United States of Department of Agriculture

AASHTO = American Association of State Highway and Transportation Officials

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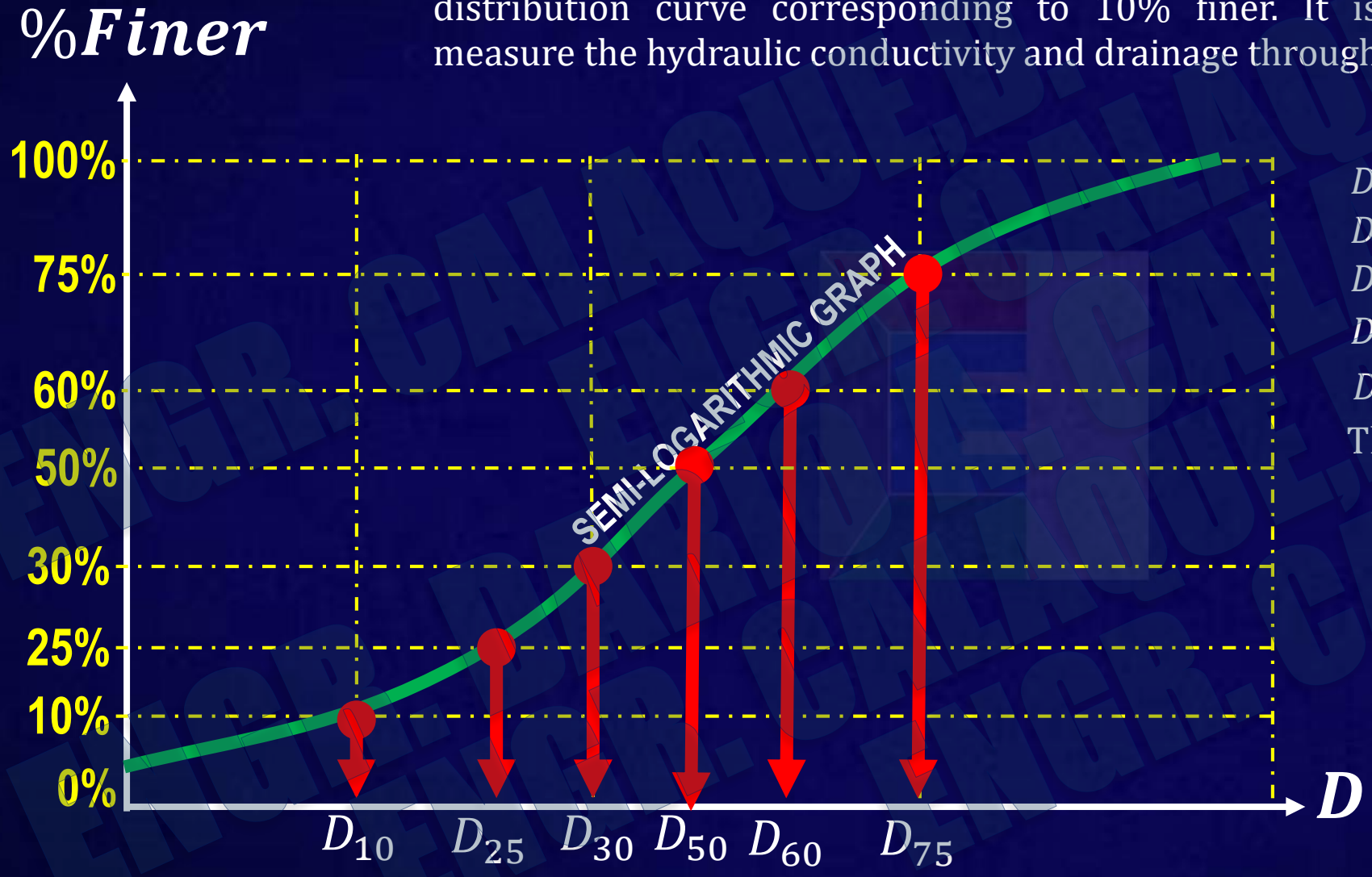
SOIL PARTICLE SIZE DISTRIBUTION

- Effective Size D_{10}: This is the diameter in the particle size distribution curve corresponding to 10% finer. It is used to measure the hydraulic conductivity and drainage through the soil.



D_{10} = corresponding to 10% finer
D_{25} = corresponding to 25% finer
D_{30} = corresponding to 30% finer
D_{60} = corresponding to 60% finer
D_{75} = corresponding to 75% finer
The average grain size of the soil is $\boldsymbol{D_{50}}$

Uniformity Coefficient:

$$C_u = \frac{D_{60}}{D_{10}}$$

Coefficient of gradation or curvature:

$$C_c = \frac{(D_{30})^2}{D_{60}\, D_{10}}$$

Sorting Coefficient, $S_0 = \sqrt{\frac{D_{75}}{D_{25}}}$

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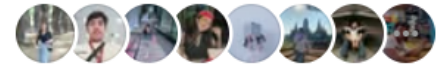

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